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(54) **Acoustical panel having a calendered, flame-retardant paper backing and method of making the same**

(57) The present invention relates to a multi-layered, substantially rigid and self-supporting acoustical panel. Preferably, the panel includes a preformed, acoustically absorbent semi-rigid core having a substantially continuous interior porosity. The panel also includes an acoustically permeable face layer applied to a first face of the preformed core, wherein the face layer is adapted to allow acoustical energy to pass through the face layer and into the acoustically absorbent core. The panel also includes a flame-retardant, calendered paper backing adapted to be applied to the preformed core. According to the present invention, the panel may also include a flame-retardant adhesive adapted to attach the calendered, flame-retardant paper backing to the preformed core.

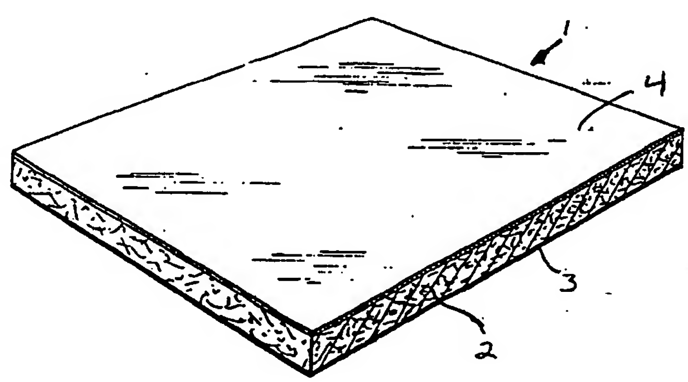

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] This invention relates to building materials, and is more particularly concerned with acoustical panels for use in ceiling and wall structures, which have good acoustical and fire retardant properties.

BACKGROUND OF THE INVENTION

[0002] Prior art acoustical ceiling or wall panels generally include an acoustically absorbent inner core, a backing material for enhancing panel strength, and front facing for enhancing the aesthetic appearance of the panel.

[0003] Typical prior art inner cores may comprise fiberglass bats formed from resin impregnated fiberglass. Other inner core materials may comprise wet-laid mineral, or slag mineral, or cellulosic fibers. Rock, slag mineral and cellulosic fibers may also utilize a variety of inorganic fillers such as perlite, clays, and gypsum. Panels designed for high acoustical absorption necessarily contain highly porous cores, achieved by using low-density bats or cores. These cores, in and of themselves, lack the necessary characteristics to function as ceiling or wall panels. Gravity may cause the inner core to deform. When starch is used as a binder for slag mineral fibers, high humidity may also weaken the panel strength. Those structural deficiencies may require the use of a backing material attached to one side of the core.

[0004] In addition to poor structural integrity, inner cores of acoustical panels are most often not sufficiently light reflective nor sufficiently uniform in shade or color to render their natural appearance aesthetically pleasing. For that reason, the inner core usually requires a decorative facing applied a face opposite the side that receives the backing material.

[0005] Although prior art porous cores are acoustically permeable and can absorb acoustical energy, some acoustical energy will inevitably be transmitted through the core and into adjacent spaces, unless the core includes a sufficient thickness and surface area to dissipate the sound as heat energy. Since sufficient surface area to completely dissipate the acoustic energy is often difficult to achieve in an economically feasible fashion, most manufacturers employ a barrier comprised of a thin layer of aluminum foil. The aluminum foil is impermeable to air and highly dense with respect to other materials within the panel and therefore increases overall sound absorption. The aluminum foil is also incombustible, which makes the foil desirable for a Class A rating in building material applications.

[0006] For example, U.S. Patent No. 3,183,996 to Capaul discloses an acoustical structural panel which includes an inner metal slag core having a paper facing with a coating of aluminum flake for the purpose of heat reflection. Similarly, U.S. Patent No. 4,627,199 to Capaul discloses a tackable acoustical structure comprising a tack pin retaining layer, a sound absorptive layer and a metal foil septum separating the tack pin retaining layer and the sound absorptive layer to enhance the sound absorbent and flame-retardant properties of the structure. Additionally, U.S. Patent No. 4,428,545 to Capaul utilizes a metallic backing which imparts enhanced sound transmission and insulation properties to a finished acoustical panel construction.

[0007] The use of a metallic foil as a backing within acoustical panels presents several problems. The first problem relates to impurities left on a finished panel product as a result of the production process. More specifically, the production process requires the use of oil in the converting process of aluminum foil prior to installation on the acoustical panel. As a result, the oil creates a black residue on the acoustical panel, which makes handling the panel quite difficult upon installation into a grid within a dropped ceiling pre-assembly. If not carefully installed, the black residue may mar the highly light reflective white face surface of the acoustical panel with smudges and stains.

[0008] Another problem associated with the use of a thin aluminum film as a backing material is the tendency of the aluminum foil to buckle and tear. Since the relative cost of aluminum is high with respect to other materials within a typical acoustical panel, it is necessary to apply only a thin foil having a thickness, for example, of only approximately 0.0015 inches. The foil may buckle or tear during the application of the foil to the core and trimming of the foil from the panel during the panel manufacturing process. Furthermore, the foil is liable to tear or become perforated during remaining production steps and even during installation by the customer. A third issue arises from the increased utilization of devices that propagate or receive transmission signals such as radios, cellular telephones and infrared control devices for lighting and heating. Aluminum and other metallic foils tend to block or interfere with signals in the electromagnetic spectrum. Thus, ceilings having panels with aluminum foil backing presents a broad metal surface in a room, over an entire floor, and often on every floor throughout an office building, which virtual renders all wireless communication devises useless within an office building.

[0009] Some have attempted to utilize paper backings within acoustical panels. For example, U.S. Patent No. 4010,817 to Warren et al. forms the acoustical panel on top of the paper by screeding the panel material onto the paper and then drying the cast pre-assembly. U.S. Patent No. 5,753,871 to Kahara uses a nearly identical process to form an inner core of mineral wool and starch binder gel to a paper backing within a molding tray to form an acoustical panel.

[0010] There are several problems associated with wet forming a material to a paper backing. First, Warren and

Kahara must re-wet the paper backing when applying a latex finish facing to the acoustical panel to avoid warping of the panel. Additionally, the manufacturing methods of Kahara and Warren also require the additional step of removing the partially finished panel from the mold for final processing. Those steps add additional cost to the manufacturing process, thus making such methods undesirable.

[0011] With the foregoing problems associated with the prior art use of metallic foils and paper backings within acoustical panels in mind, it is a general object to create an acoustical panel with a paper backing having desirable acoustical sound absorption properties, while being simple and inexpensive to manufacture.

SUMMARY OF THE INVENTION

[0012] The present invention relates to a multi-layered, substantially rigid and self-supporting acoustical panel. Preferably, the panel may include a preformed, acoustically absorbent semi-rigid core having a substantially continuous interior porosity. The panel may include an acoustically permeable face layer applied to a first face of the preformed core, wherein the face layer is adapted to allow acoustical energy to pass through the face layer and into the acoustically absorbent core. The panel may also include a calendered paper backing adapted to be applied to the preformed core. The paper backing may include a flame-retardant material, and should be substantially free of any metallic material. According to the present invention, the panel may also include a flame-retardant adhesive adapted to attach the calendered, flame-retardant paper backing to the preformed core.

[0013] In one embodiment of the present invention the core may comprise an acoustically a fiberglass bat, wherein the bat is bound into a semi-rigid state with a resin material. The core may also include slag mineral fiber, cellulosic fiber or polymeric fiber materials having a filler of clay, perlite, gypsum or any other material suitable for filling purposes. Additionally, any number of binders would be suitable for the aforementioned fillers including starches or polymeric resins. In addition to the above-referenced materials, acoustically absorbent core may comprise a cemetitious or polymeric foam having any number of filler materials. The core material may also comprise bound aggregate particles.

[0014] In one embodiment, the face layer may comprise an air permeable scrim material adhered to the panel core with poly (vinyl acetate) glue. In other embodiments, the facing may include the scrim with a layer of paint applied thereto. Other embodiments of the present invention may include a face layer comprising a perforated polymeric film for allowing permeation of acoustical energy therethrough and into the acoustically absorbent core. One example of many possible polymeric materials for use as a face layer on the panel may include a polyvinylchloride (PVC) film. Additionally, the PVC film may receive an air permeable layer of paint in another embodiment of the present invention.

[0015] The invention also comprises a method of manufacturing a multi-layered, substantially rigid and self-supporting acoustical panel comprising the steps of: providing a preformed, acoustically absorbent semi-rigid core having a first face and a second face disposed opposite the first face, applying a flame-retardant adhesive to the first face of the core, applying a sheet of calendered, flame-retardant paper to the adhesive on the first face of said core, applying compressive force to the flame-retardant paper and adhesive to insure bonding between the paper and core, applying heat to the core and paper to cure the adhesive; and applying a finishing layer to the second face of the core.

[0016] These and other features of the present invention will become apparent upon reading the following specification, when taken in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a sectional view of a ceiling panel according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Figure 1 illustrates an acoustical ceiling panel 1 according to the present invention. The acoustical panel includes an essentially three layered, self-supporting, laminated structure in which a core 2 is a porous bat or panel composed of fibers and/or fillers held together with a binder. Core 2 may comprise any type of fibers, including, but not limited to fiberglass fibers, cellulosic (natural) fibers, metallic slag fibers or polymeric fibers. Core 2 may also comprise a cementitious or polymeric foam reinforced with the above-referenced fibers, or may comprise bound aggregate particles. The core may also include fillers such as, but not limited to, cellulosic perlite, or clay materials. In a preferred embodiment, however, the core may comprise a prefabricated, low density, 2-10 lb./ft^3, fiberglass bat, typically bound with a phenolic resin. In another embodiment, the panel may comprise a rock or slag mineral fiber panel typically bound with starch or latex. Mineral fiber, starch-bound panels are typically more dense, having a density of 8-20 lb/ft^3. In accordance with the present invention core 2 may comprise virtually any material combination as long as enough continuous porosity is present to achieve the acoustic absorbency as set forth below.

[0019] An acoustically permeable face layer 3 is applied to the one side of the bat core or panel, which may be a lightly painted scrim, a woven or non-woven fabric, a perforated polymeric film, a perforated membrane, or a discontinuous paint coat which allows for the permeation of acoustic energy into the absorbent core 2. If the face layer 3 comprises a film or membrane, a flame-retardant adhesive may attach the face layer 3 to the core 2.

[0020] Finally, a calendered, flame-retardant paper 4 is applied to the back of the surface of the core with a flame-retardant adhesive, and acts as a barrier to sound transmission through the structure.

[0021] A structure according to the present invention has been reduced to practice and well tested as set forth below in Example 1. The paper backing provides sufficient air-flow resistance to render to the panel a CAC value equal to that of the same structure backed with a 0.0015 in. thick aluminum foil.

Example 1

[0022] Example 1 utilized as a face layer 3 an Owens-Corning fiberglass scrim having an unpainted air permeability of 150 $ft^3/ft^2/min$. The scrim received a layer of paint equal to approximately 36 g/m^2. The paint comprised an Armstrong Durabrite latex paint. In order to adhere the scrim to the core 2, the inventors utilized a flame retarded poly (vinyl acetate) glue. The glue composition comprised a brominated aromatic oxide and a metallic flame-retardant material at approximately 25% by weight within the glue. Other flame-retardant materials suitable for use with the poly (vinyl acetate) glue may include other halogenated fire suppressants; hydrated inorganic compounds such as aluminum trihydrate, magnesium hydroxide, calcium borate, and zinc borate; intumescent phosphate compounds such as ammonium polyphosphate; organic and inorganic phosphate compounds such as ammonium sulfate, other sulfate and sulfamate compounds; and free radical scavenger materials such as antimony trioxide. Other suitable adhesives may include, but are not limited to, polyvinyl alcohol, starch, and waterborne lattices such as acrylic, styrene-acrylate or ethylene vinyl chloride dispersions. Non-waterborne polymeric systems, such as acrylates and methacrylates may also be suitable for use as adhesives.

[0023] The core 2 comprised a 1-in, thick phenolic-bound fiberglass batting having a density of approximately 5.0 lb/ft^3.

[0024] The paper backing 4 comprised a calendered paper having a thickness of 0.0029 in., had a basis weight of 50 lb./3000 ft^2, included a flame-retardant system comprised of ammonium sulfate and inorganic salts, and was manufactured by Pepperell, Inc., of Pepperell, Massachusetts 01463.

[0025] The basis weight paper is an expression of mass of paper per unit area. Calendering does not change basis weight. Calendering changes the paper density by decreasing and compressing the paper thickness. For example, calendering of the paper moves the paper density from approximately twelve (12) pounds per point of thickness to approximately fifteen (15) pounds per point of thickness. Thus, the calendered paper used in Example 1 had a density of approximately 68.9 lbs per $ft.^3$, whereas the density of an uncalendered paper having the same basis weight would be approximately 53.4 lbs per ft^3. The porosity of the uncalendered paper having the same basis weight is approximately three (3) times greater. The paper manufacturer utilized the TAPPI T460om-83 and T536cm-85 test protocols to test the porosity of the calendered paper in Example 1. The TAPPI T460om-83 and T536cm-85 tests yield a value of approximately one hundred ten (110) seconds for one hundred 100 cubic centimeters (cc) of air to pass through the calendered paper at the standard test pressure drop under testing conditions and parameters called out in the above-referenced TAPPI test protocols. As a basis of comparison, uncalendered paper having the same composition and basis weight as paper used in Example 1 has a porosity test value of approximately thirty six (36) seconds.

[0026] The flame-retardant system material of ammonium sulfate and inorganic salts comprised 11-13% by mass of the paper utilized in Example 1. Other suitable flame retardant materials for use in the calendered paper may include, but are not limited to, hydrated materials such as aluminum trihydrate and calcium borate, intumescent (char formers) such as diammonium phosphate and urea-phosphate, and vapor phase free radical scavengers such as antimony trioxide. Sulfate or sulfamate compounds, such as ammonium sulfate also flame retard cellulosics.

[0027] Table 1 illustrates CAC test results for the sample made in Example 1. The results of Table 1 indicate the measure of sound transmission loss obtained for three different lots of this paper backed composite. Essentially, in this test, sound is transmitted into the face side of the composite panel over a range of frequencies and the decibel reduction at each frequency is measured on the other side of the panel. Results of tests on two lots of such a composite backed instead with standard 0.00 15" thick aluminum foil are given for comparison. Equivalent performance is evident.

					Table 1							
Paper-backed Panel	Test 1		Paper-backed Panel	Test 2	Paper-backed Panel	Test 3	Foil-backed Panel	Test 1		Foil-backed Panel	Test 2	
Freq (Hz)	Threshold Loss (dB)	Deficiencies	Freq (Hz)	Threshold Loss (dB)	Freq (Hz)	Threshold Loss (dB)	Freq (Hz)	Threshold Loss (dB)	Deficiencies	Freq (Hz)	Threshold Loss (dB)	Deficiencies
125	21.86	0	125	19.9	125	21.3	125	22.00	0	125	20.56	0
160	24.19	0	160	24.1	160	23.5	160	25.21	0	160	21.70	0
200	23.58	0	200	23.3	200	22.6	200	23.97	0	200	21.51	0
250	26.20	0	250	25.7	250	25	250	26.73	0	250	24.30	0
315	24.18	0	315	23.7	315	24.1	315	23.05	1	315	22.09	3
400	24.23	3	400	27.2	400	26	400	19.17	8	400	23.57	4
500	23.34	5	500	29.2	500	26.1	500	21.67	6	500	25.35	4
630	21.03	8	630	23.2	630	21.7	630	28.51	0	630	23.25	7
800	23.62	6	800	22.8	800	24.4	800	31.57	0	800	26.08	5
1000	31.77	0	1000	30.4	1000	33.8	1000	30.37	1	1000	35.26	0
1250	30.69	1	1250	34.7	1250	31.7	1250	31.40	1	1250	32.77	0
1600	29.95	2	1600	30.8	1600	30.4	1600	31.87	0	1600	30.64	2
2000	31.19	1	2000	33.3	2000	31.2	2000	34.80	0	2000	31.07	2
2500	34.73	0	2500	33.8	2500	33.4	2500	36.63	0	2500	35.68	0
3150	37.74	0	3150	39.5	3150	36.3	3150	40.02	0	3150	40.21	0
4000	41.45	0	4000	43	4000	39.3	4000	43.01	0	4000	43.46	0
	CAC-28			CAC-29		CAC-29		CAC 28			CAC 28	
	Def 26			Def 21		Def 21		Def 17			Def 28	

[0028] Table 2 illustrates the noise reduction coefficient (NRC) test results for the same lot of material tested for CAC in Example 1. These results demonstrate the ability of this paper-backed composite to absorb a high level of sound from within the room in which it is installed.

Table 2

NRC Test	
Frequency (Hz)	Absorption Coefficient
100	0.44
125	0.42
160	0.45
200	0.45
250	0.53
315	0.63
400	0.88
500	1.00
630	0.97
800	0.94
1000	1.04
1250	1.09
1600	1.11
2000	1.08
2500	1.09
3150	1.06
4000	1.04
5000	1.03
4 Freq Avg	**0.913**
NRC	**0.90**

[0029] Table 3 illustrates Steiner Tunnel test results performed on the panel made in accordance with Example 1. The Steiner Tunnel, designated ASTM E-84, is a measure of flame-spread and smoke generation of a building material. In the Steiner Tunnel test, a material is inserted above a 25 foot tunnel. A controlled air velocity is established in the tunnel and the material is ignited at one end. The flame front is measured with time as it travels down the tunnel and amount of smoke generated is measured as it exits the tunnel. Flame-spread and smoke values are calculated from the data. A flame-spread value of 25 or under and a smoke value of 50 or under "Class A" rating is required for the majority of ceiling panels and that is the goal for this invention.

Table 3

Material Slit or not	Glue Type	Glue Application	Flamespread Value	Smoke Value
No	FA2AB	3.8 g/ft^2	25	15
No	Fuller	4.1 g/ft^2	35 fail	10
No	FA2AB	3.75 g/ft^2	23	13
No	FA2AB	4.5 g/ft^2	15	7
No	FA2AB	5.2 g/ft^2	13	3

Table 3 (continued)

Material Slit r not	Glue Type	Glu Application	Flamespr ad Value	Smoke Value
No	FA2AB	5.5 g/ft^2	5.04	7.06
Yes	FA2AB	5.5 g/ft^2	10.08	8.1
Yes	FA2AB	5.5 g/ft^2	10.05	5.95

[0030] Our experimental results indicate that the calendered, flame-retardant paper in our invention performs equal to aluminum foil in the reduction of sound transmission, and serves to alleviate the problems and expense of using a metallic foil.

[0031] The process of making the inventive tile includes the first step of laminating the paper backing to the fiberglass core in a continuous fashion. In Example 1, the inventors utilized prefabricated 4ft.by 8ft fiberglass cores transported down a production line by a conveyor. It will be apparent to the ordinarily skilled artisan that one may use a core of virtually any size. As the bats progress down the production line, an application roller receives the adhesive and applies the adhesive in a continuous, roll-coating fashion onto the bats.

[0032] A roll of paper disposed above the production line feeds the paper backing to the glue-laden cores in a continuous manner. Next, a mating roll passes over the core-backing subassembly. The subassembly then passes through a double-surface pressure conveyor, which further compresses the paper backing onto the core and assures a smooth, wrinkle-free application and full contact between the paper and the core.

[0033] A series of air convection blowers then apply heat to the core and backing to cure the adhesive. The core and paper subassembly then passes beneath, but not in contact with a heated roll for further curing. Finally, the core and paper subassemblies travel through a gas-fired oven set to 200° F for several minutes to complete the drying and curing.

[0034] A slitting operation then slits the paper to size between the core-paper subassemblies. The operation then trims the subassembly edges, and inverts and stacks each subassembly. The subassemblies then travel down the line again in a second pass, in which the production line applies a scrim face to the opposite face of the core. In this pass, the production line lowers the heating roll down to contact the scrim surface on the core. Following application of the heated roll, spayers on the production line apply the paint to the scrim. Next, a gas-fired oven dries the paint. The production process then cuts each panel to size and packages the panels.

[0035] While preferred embodiments have been illustrated and described above, it is recognized that variations may be made with respect to features and components of the invention. Therefore, while the invention has been disclosed in preferred forms only, it will be obvious to those skilled in the art that many additions, deletions and modifications can be made therein without departing from the spirit and scope of this invention, and that no undue limits should be imposed thereon except as set forth in the following claims. For example, it is contemplated that many types of materials may comprise the core of the inventive panel, as described above. Additionally the present invention is not limited to ceiling tiles, but may include wall structures and tackable surfaces.

Claims

1. A multi-layered, substantially rigid and self-supporting acoustical panel comprising:

    a preformed, acoustically absorbent semi-rigid core having a substantially continuous interior porosity, said core having first face, a second face disposed opposite the first face and a perimeter edge portion separating said first and second faces;
    an acoustically permeable face layer applied to said first face of said preformed core, wherein said face layer is adapted to allow acoustical energy to pass through said face layer and into said acoustically absorbent core;
    a calendered paper backing adapted to be applied to said preformed core, said paper backing including flame-retardant material therein, and wherein said paper backing is substantially free of any metallic material; and
    an adhesive adapted to attach said calendared, flame-retardant paper backing to said preformed core.

2. The acoustical panel of claim 1 further comprising:

    a flame retardant within said adhesive.

3. The acoustical panel of claim 1 wherein said calendered paper has a density of at least approximately 68.9 lb./ft.^{3}.

4. The acoustical panel of claim 1 wherein said calendered paper has a TAPPI porosity of at least approximately 110

seconds.

5. The acoustical panel of claim 1 further comprising:

an acoustically absorbent core formed from a fiberglass bat, wherein said bat is bound into a semi-rigid state with a resin material.

6. The acoustical panel of claim 1 further comprising:

an acoustically absorbent core formed from a slag mineral fiber material.

7. The acoustical panel of claim 1 further comprising

an acoustically absorbent core formed from cellulosic material.

8. The acoustical panel of claim 1 further comprising:

an acoustically absorbent core formed from a polymeric fiber material.

9. The acoustical panel of claim 1 further comprising:

an acoustically absorbent core formed from a cemetitious foam.

10. The acoustical panel of claim 1 further comprising:

an acoustically absorbent core formed from bound aggregate particles.

11. The acoustical panel of claim 1 wherein said face layer comprises:

an air permeable scrim material; and
a flame-retardant adhesive for adhering said scrim to said preformed core.

12. The acoustical panel of claim 1 wherein said flame-retardant adhesive comprises:

a poly (vinyl acetate) glue.

13. The acoustical panel of claim 11 further comprising:

a layer of paint applied to said scrim material.

14. The acoustical panel of claim 1 wherein said face layer comprises:

a perforated polymeric film for allowing permeation of acoustical energy therethrough and into said acoustically absorbent core.

15. The acoustical panel of claim 1 wherein said face layer further comprises:

a polyvinylchloride film.

16. The acoustical panel of claim 1 wherein said face layer comprises:

an air permeable layer of paint.

17. The acoustical panel of claim 1 wherein said panel exhibits a CAC test threshold noise loss of up to approximately 22 dB at for a test noise frequency of approximately 125 Hz.

18. The acoustical panel of claim 1 wherein said panel exhibits a CAC test threshold noise loss of up to approximately 43 dB at a noise frequency of approximately 4000 Hz.

19. The acoustical panel of claim 1 wherein said calendered, flame-retardant paper includes a basis weight of approximately 30 to approximately 70 lb./3000 ft^2.

20. The acoustical panel of claim 1 wherein said calendered, flame-retardant paper includes a flame-retardant material constituent comprising approximately 11-13% by mass of said paper.

21. A method of manufacturing a multi-layered, substantially rigid and self-supporting acoustical panel comprising the steps of:

providing a preformed, acoustically absorbent semi-rigid core having a first face and a second face disposed opposite the first face.
applying a flame-retardant adhesive to the first face of the core;
applying a sheet of calendered, flame-retardant paper to the adhesive on the first face of said core;
applying compressive force to the flame-retardant paper and adhesive to insure bonding between the paper and core;
applying heat to the core and paper to cure the adhesive; and
applying a finishing layer to the second face of the core.

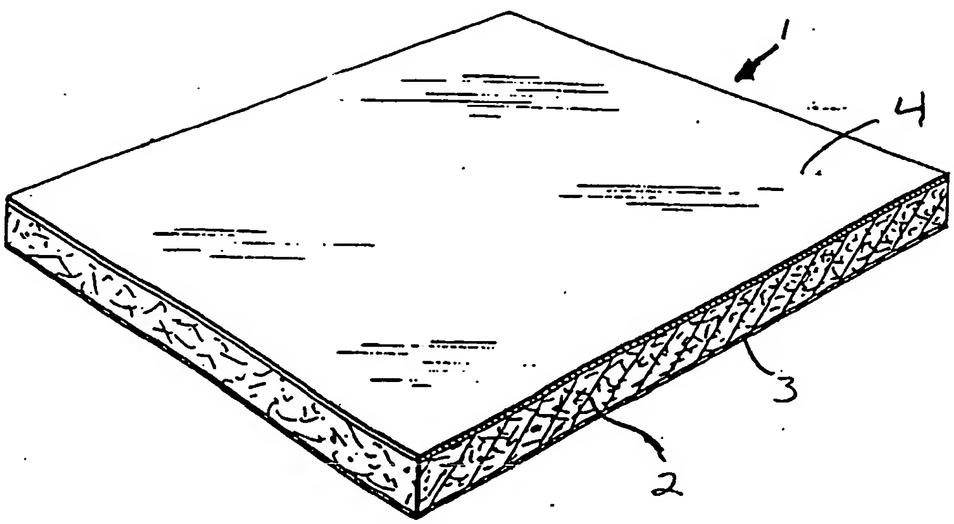

Fig. 1